July 24, 1962 S. B. COHN 3,046,503

BROAD-BAND WAVEGUIDE FILTER

Filed May 27, 1960 2 Sheets-Sheet 1

FIG. 1

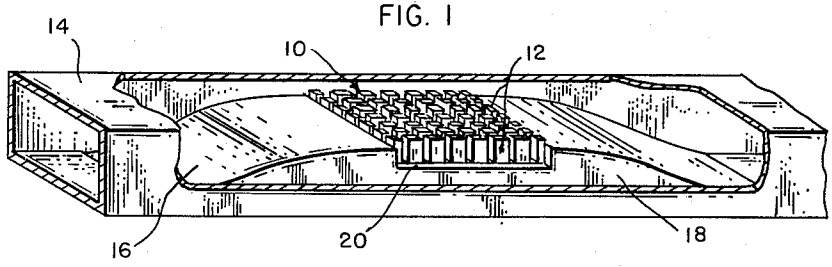


FIG. 2

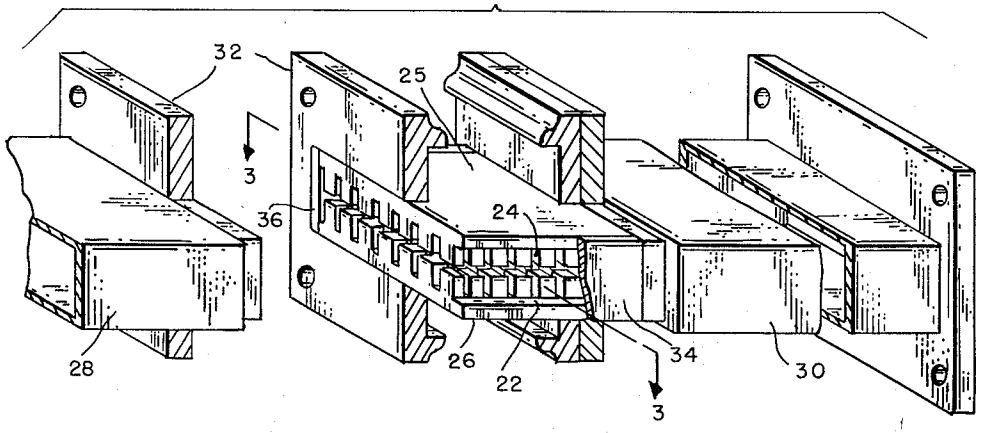
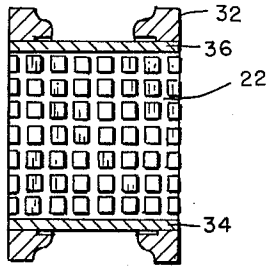


FIG. 3



INVENTOR,

SEYMOUR B. COHN

BY Harry M. Saragovitz

ATTORNEY.

July 24, 1962 S. B. COHN 3,046,503

BROAD-BAND WAVEGUIDE FILTER

Filed May 27, 1960 2 Sheets-Sheet 2

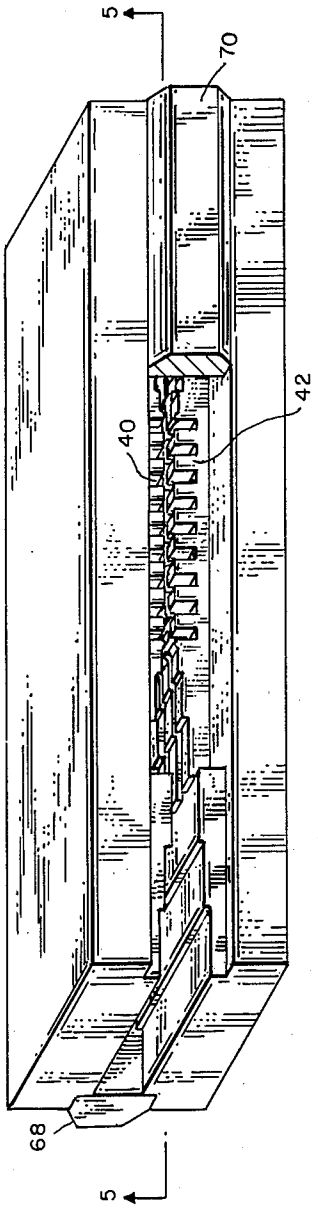


FIG. 4

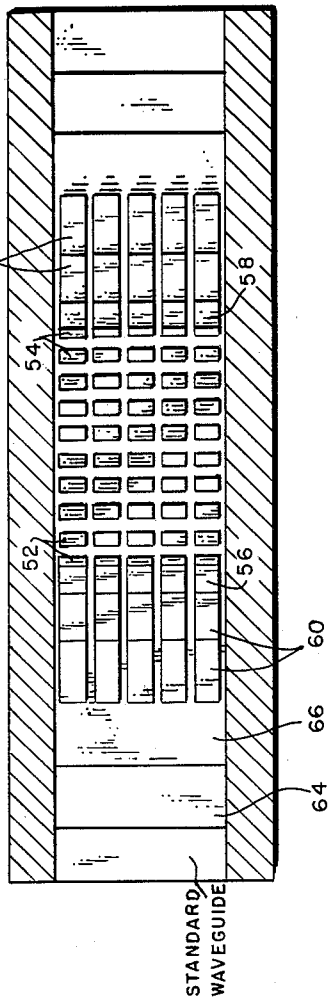


FIG. 5

INVENTOR,
SEYMOUR B. COHN

BY
Harry M. Saragovitz
ATTORNEY.

United States Patent Office 3,046,503 Patented July 24, 1962

3,046,503

BROAD-BAND WAVEGUIDE FILTER

Seymour B. Cohn, Palo Alto, Calif., assignor to the United States of America as represented by the Secretary of the Army

Filed May 27, 1960, Ser. No. 32,499
1 Claim. (Cl. 333—73)

This invention relates to broad-band waveguide filters and more particularly to an improved corrugated rectangular waveguide filter.

In the so called "varying impedances" class of waveguide filters, the height of the rectangular waveguide is stepped by means of transversely disposed ridges to give alternate high and low characteristic impedance regions and thus provide a low-pass filter type of cut-off. Such filters are known in the art as corrugated rectangular waveguide filters. The band-pass of this type filter extends from the cut-off frequency of the waveguide up to the cut-off frequency of the stepped filter structure. Above this second cut-off frequency it is generally desired that the stop band extend to as high a frequency as possible without spurious responses. However, it has been found that pass bands occur for the higher order TE_{n0} modes whenever the guide wavelength of one of these modes is greater than the cut-off guide wavelength of the dominant mode. This in many cases causes spurious transmission regions in the desired stopband of the filter. While it is recognized that this type of spurious response can be eliminated by using two or more groups of filter sections in different width waveguides, such structures have proved rather difficult to construct and the discontinuities at the changes in width usually cause a poor band-pass response.

It is an object of the present invention to provide an improved filter structure of simpler design wherein the responses to higher waveguide modes is completely eliminated.

It is another object of the present invention to provide an improved corrugated type filter which is relatively easy to build and characterized by a very wide stop band free of spurious responses and an excellent band-pass response.

It is another object of the present invention to provide an improved corrugated waveguide filter having a filter response dependent on frequency rather than on the guide wavelength of any mode.

In accordance with one embodiment of the invention there is provided a broad-band filter which includes a rectangular waveguide, a pair of spaced transition sections within said waveguide and a high-frequency band-pass filter having a recessed base portion from which there extends upwardly a plurality of spaced bosses. In this embodiment the band-pass filter structure is unsymmetrical in the E-plane of the rectangular waveguide.

In accordance with another embodiment of the invention the band-pass filter includes a pair of mutually opposed surfaces each comprised of a plurality of spaced bosses. The opposing bosses are symmetrically arranged so that the band-pass filter is symmetrical in the E-plane of the waveguide.

For a better understanding of the invention, together with other and further objects thereo, reference is had to the following description taken in connection with the accompanying drawings in which:

FIG. 1 illustrates one embodiment of the invention, partially cut-away, showing the filter structure asymmetrical in the E-plane;

FIG. 2 illustrates another embodiment of the invention, partially cut-away, showing the filter structure symmetrically arranged in the E-plane;

FIG. 3 is a cross-section of the filter section taken along the line 3—3 of FIG. 2;

FIG. 4 is a perspective view, partially cut-away, showing a preferred filter structure symmetrically arranged in the E-plane; and

FIG. 5 is a cross-section of the filter section taken along the line 5—5 of FIG. 2.

Referring now to FIG. 1 of the drawing, the waveguide filter includes a metallic filter portion **10** positioned between the top and bottom walls of rectangular waveguide **14**, and a first and second tapered transition section **16** and **18** connected respectively between one end of waveguide **14** and one end wall of the filter portion **10**. The filter portion **10** comprises a plurality of rectangular shaped bosses **12** having a square or rectangular cross-sectional area and which extend upwardly from a base portion **20**. As shown, the filter base portion **20** is recessed between the tapered transition sections. The bosses **12** are arranged colinearly in rows parallel to the longitudinal and transverse axes of waveguide **14**. The rectangular shaped bosses **12** are formed by first cutting a prescribed number of spaced transverse slots having a prescribed width and depth and then cutting longitudinal slots of the same or other depth and width spacing. The longitudinal rows of bosses are uniformly spaced as are the transverse rows of bosses, with the spacing between longitudinal and transverse rows of bosses being of the same or different width and depth. The number of bosses in a transverse row across the guide **14** is a function of the accuracy and the required tolerances of the bosses and also a function of the width of the stop band desired. As shown, a transverse row of bosses terminates the filter portion **10** at both ends in the E-plane. The cross-sectional area of the bosses in the terminating ends are made less than the cross-sectional area of the remaining bosses in order to provide a better match to the tapered transition sections **16** and **18** so that the filter-image impedance remains substantially constant in the pass band. The longitudinal rows of bosses which respectively terminate the sides of the filter portion are spaced from the side walls of waveguide **14** by a distance which is substantially one-half the width of the longitudinal slots. The center-to-center distance between adjacent transverse rows of bosses is considered to be one full section of the filter portion **10**. As shown, the transition from one end of filter portion **10** to one end of waveguide **14** is provided by the tapered section **16**, while tapered section **18** provides the transition from the other end of filter portion **10** to the other open end of guide **14**. It is to be understood, of course, that stepped transformers may be used in place of the smooth transition sections shown. The number of sections required for filter portion **10** is a function of the desired sharpness of cut-off above the upper frequency edge of the pass band.

FIGS. 2 and 3 illustrate a filter structure which is symmetrical in the E-plane. In FIGS. 2 and 3, two identical filter portions **22** and **24** are utilized with the bosses of one filter portion opposing the bosses of the other filter portion, and with the longitudinal and transverse slots of one filter portion being symmetrical with the respective longitudinal and transverse slots of the second filter portion. Since each of the filter portions **22** and **24** is identical in construction to the filter **10** shown in FIG. 1, a detailed description thereof is not necessary. The flat or base section **25** and **26** of each filter portion are oppositely disposed as shown. The two mutually opposed filter portions are spaced from each other and supported in position by any sutiable means well known in the art. The complete filter is affixed to the transition waveguides **28** and **30** by means of flanges shown at **32**. Side walls **34** and **36** are provided in the filter section, these walls being spaced from the first and last longitudinal row of bosses by a distance which is substantially one-half the

width of the longitudinal or transverse slots. As shown, the side walls 34 and 36 are respectively affixed between the mounting flanges 32 of the filter portion shown in FIG. 2.

In order to better understand the operation of the improved filter shown in FIGS. 1 and 2, the filter may be considered first without the longitudinal slots, i.e., transverse slots only. Such transverse slots in the filters are characteristic of the conventional varying-impedance waveguide filter, and without the longitudinal slots, the structure does not vary across the width of the waveguide and, therefore, according to basic waveguide theory, the response of the structure is a function of guide wavelength λ_g only for any TE_{n0} mode. Thus, if the filter cuts off at λ_{gl}, for the TE_{10} mode, it will also cut off at this same guide wavelength for the TE_{20} mode, TE_{30} mode, etc. Hence, for each mode there will be a pass band between the cut-off frequency of this mode, and the frequency at which the guide wavelength of this mode is equal to λ_{gl}.

The fact that the higher-mode responses do not occur in the filter having both transverse and longitudinal slots may best be seen by considering it to be a two-dimensional artificial dielectric. Each mode of the TE_{n0} class may be assumed to consist of a pair of uniform plane waves travelling diagonally with respect to the longitudinal axis of the waveguide. Inside the filter structure, each plane wave will have a cut-off frequency below which the wave will travel freely, and above which it will travel with a high reactive attenuation. The particular value of the filter cut-off frequency will vary somewhat with the direction of the wave with respect to the axes of the structure, but this variation will be small in structures of practical interest since the periodicity of the structure is small compared to the free-space wavelength at cut-off. Therefore, the cut-off frequency for each member of the TE_{n0} class of modes will be approximately the same as that for the TE_{10} mode. Thus there will be no separate responses for the higher modes. Furthermore, the filter cut-off will usually be designed to occur below the cut-off frequency of the TE_{20} mode in the terminating waveguide, and hence no higher-mode pass bands can exist at all.

Another advantage of the new filter structure is that it is much easire to assemble. In the older structure having only transverse slots, the side walls must be soldered perfectly to the grooved top and bottom walls, since even a slight gap along the edges of the corrugations can introduce considerable dissipation loss and reflection loss in the pass band. In the new structure, longitudinal slots can be introduced along the sides, as shown in FIG. 2, so that solder does not have to run up the edges of the corrugations. In this case the adverse effect of a moderately imperfect soldering job will be negligible, and therefore the assembly process can be greatly simplified. In fact, excellent performance has been obtained with the new filter with its parts merely bolted together without solder. In cases where changes in width had to be used in the older structure to eliminate higher-mode responses the simplification is even greater.

Although the bosses in FIGS. 1–3 are shown as rectangular in cross-section, it is to be understood that the invention is not to be limited thereto nor is it to be limited to slots which intersect at right angles. For example, the spaced bosses may be circular, triangular, or hexagonal, etc., in cross-section and the slots may intersect at 60 degrees and still operate efficiently as a broad-band microwave filter.

FIGS. 4 and 5 illustrate another embodiment of a filter which is symmetrical in the E-plane. As in the filter section of FIG. 2, two identical filter portions **40** and **42** are provided with the bosses of filter portion **40** opposing the bosses of filter portion **42** and with longitudinal and transverse slots of filter portion **40** being symmetrically arranged with respect to the longitudinal and transverse slots of filter portion **42**. Since both filter portions are identical, only one will be described.

Referring now to FIGS. 4 and 5, respective longitudinal rows of bosses are terminated at each end by terminating end boss sections **52** and **54**, which, in turn, are terminated by end waveguide boss sections as at **56** and **58**. The waveguide boss sections **56** and **58** are in turn terminated by stepped boss sections **60** and **62** which form part of the transition sections coupling an external waveguide to the filter. As shown, the respective loingitudinal slots extend through their associated terminating end sections, their associated terminating end waveguide sections and their associated stepped boss sections. The remainder of each transition section includes transverse steps **64** and **66** which couple standard waveguides to the filter input and output. The filter portions **40** and **42** are maintained in spaced relationship by means of end wall **68** and **70** as shown in FIG. 4. The terminating end boss sections and end waveguide boss sections together with the stepped transformer sections provide a suitable match between the input and output waveguides and the filter so that a good VSWR response is achieved for the filter pass band.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

A broad band microwave filter comprising a section of rectangular waveguide having a longitudinal and transverse axis, a first section comprising a plurality of spaced conductive bosses within said waveguide section and extending upwardly from one wide surface thereof, a second section comprising a plurality of spaced conductive bosses extending downwardly from the other wide surface of said waveguide section in mutual opposition to and symmetrically arranged with said upwardly extending bosses, the bosses in said first and second sections being arranged colinearly in a plurality of spaced rows, said rows being parallel to said longitudinal and transverse axes and coextensive with the width of said waveguide section, the free ends of said oppositely arranged bosses being spaced from each other along the narrow dimension of said waveguide section, and a first and second transition section respectively terminating the ends of said first and second sections.

References Cited in the file of this patent

UNITED STATES PATENTS

2,888,598	Palluel	May 26, 1959
2,912,695	Cutler	Nov. 10, 1959

OTHER REFERENCES

Greene: "Corrugated-Waveguide Band-Pass Filters," Electronics Magazine, vol. 24, No. 7, pages 117–119, July 1951.